BULLETIN

OF THE

Society for the Promotion of Engineering Education

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EDITORIALS.

Teaching Physics to Engineering Students.—The paper by Professors Franklin and MacNutt is intended to draw attention to some of the inconsistencies in our present methods of imparting instruction in this fundamental subject. As science is the basis of engineering it is essential that physics be well taught. One purpose of the paper is to stir up discussion and the BULLETIN will print contributions as promptly as possible after they are received. The Society has devoted considerable attention to the teaching of mathematics and as a result a

useful syllabus has been prepared. A syllabus of physics, covering those elements which are essential to a good working knowledge of the subject, would be very useful and might well be a result of this discussion.

Complex Quantities.—At the Pittsburgh meeting a number of members expressed the opinion that complex quantities should be covered in the mathematics syllabus as they are useful in several branches of engineering. As Professor Gunther was strongly of this opinion he was requested to prepare a brief outline to be appended to the report of the Committee on the Teaching of Mathematics to Engineering Students. While it is too late to add material to the discussion now being printed in the *Proceedings*, readers of the BULLETIN are invited to contribute examples of the applicability of complex quantities to engineering problems.

The Year-book.—A study of the tables printed in the February BULLETIN shows that the number of teachers in the membership is not increasing greatly, although there is a marked increase in the number of non-teaching engineers and business men. It may be that practically all of the available teachers are now members, but this seems hardly possible. With each copy of the January BULLETIN sent to the members a return postal card was enclosed. This contained blank spaces for filling in the names of possible members to whom the Secretary could extend invitations and send printed matter. A few cards have come in and members are requested to assist the Membership Committee by returning the balance promptly.

The Annual Meeting.—It has been definitely decided to hold the meeting in Boston from June 25 to 27 inclusive. A tentative program has been prepared and the committee in charge is arranging for papers in line with the general plan. There will be no opportunity afforded this year for papers on miscellaneous topics. For this reason members who have in mind to present papers dealing with particular topics are

urged to send these to the BULLETIN early. One of the functions of the monthly journal is to publish papers which cannot be presented at the annual meeting for lack of time. The purpose of the program to be followed this year is to produce a definite result by concentration upon a few topics with ample opportunity for oral and written discussion. The preliminary program is printed in this issue. The Program Committee hopes that a large number of members are planning to be present for, after all, the most important function of the meeting and of the Society itself is to promote friendliness and a spirit of coöperation among the members.

NEW MEMBERS.

By letter ballot the Council has elected the 10 applicants listed on p. 221 of the January BULLETIN as well as the following:

ADAMS, F. J., Instructor in Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1912

ADAMSON, K. F., Instructor in Mechanical Engineering, University of Pennsylvania, Philadelphia, Pa. 1912

ANDREWS, W. H., Assistant Professor of Mathematics, Kansas State Agricultural College, Manhattan, Kans. 1912

BAHNEY, L. W., Assistant Professor of Metallurgy, Sheffield Scientific School, Yale University, New Haven, Conn. 1912

BATES, J. T., Assistant Professor of Mechanical Engineering, Iowa State College, Ames, Ia. 1912

BENEDICT, B. W., Director of Shop Laboratories, Mechanical Engineering Dept., University of Illinois, Urbana, Ill. 1912

BUYERS, A. S., Instructor in Mechanical Engineering, University of Illinois, Urbana, Ill. 1912

CRUM, R. W., Assistant Professor of Civil Engineering, Iowa State College, Ames, Ia. 1912

EMERSON, WM. H., Dean and Professor of Chemistry, Georgia School of Technology, Atlanta, Ga. 1912

FESSENDEN, E. A., Assistant Professor of Mechanical Engineering, University of Missouri, Columbia, Mo. 1912

FULTON, C. H., Professor of Metallurgy and Head of Mining Dept., Case School of Applied Science, Cleveland, O. 1912

GUSTAFSON, LEWIS, Superintendent, The David Ranken, Jr. School of Mechanical Trades, St. Louis, Mo. 1912

HERTY, C. H., Professor of Chemistry, University of North Carolina, Chapel Hill, N. C. 1912
HOERNING, CARLOS, Professor of Mechanical Engineering, Universidad de Chile, Santiago, Chile. 1912
KNEALE, R. D., Professor of Civil Engineering, Montana State College of A. & M. Arts, Bozeman, Mont. 1912
KNAPP, E. R., Professor of Descriptive Geometry and Mechanical Drawing, Stevens Institute of Technology, Hoboken, N. J..... 1912
LAGERGREN, J. T., Lecturer of Machine Design, University of Toronto, Toronto, Ont., Canada. 1912
MARSHALL, W. C., Assistant Professor of Machine Design, Sheffield Scientific School, Yale University, New Haven, Conn. 1912
MICHIE, J. N., Assistant Professor of Mathematics, Texas, A. & M. College, College Station, Texas. 1912
OWEN, C. H., Principal of the Apprentice Trade School, The Warner & Swasey Company Trade School, Cleveland, O. 1912
PENNOCK, R. M., Instructor in Mechanical Engineering, Pennsylvania State College, State College, Pa. 1912
PORTER, F. M., Instructor in Engineering Drawing, University of Illinois, Urbana, Ill... 1912
RORTY, M. C., Manager, Commercial Methods Office, American Telephone & Telegraph Co., New York, N. Y. 1912
STILLWELL, L. B., Consulting Engineer, 100 Broadway, New York, N. Y. 1912
WALKER, WM. H., Professor of Chemical Engineering, Massachusetts Institute of Technology, Boston, Mass. 1912

APPLICANTS FOR ADMISSION.

EARLE, S. B., Director of the Engineering Department, and Professor of Mechanical Engineering, Clemson Agricultural College, Clemson College, S. C. 1912
HOWLETT, C. A. S., General Electric Co., Schenectady, N. Y. 1912
SCHWARZE, C. T., Assistant Professor of Civil Engineering, Cooper Union, New York, N. Y. 1912
SMALLWOOD, J. C., Associate Professor of Mechanical Engineering, Syracuse University, Syracuse, N. Y. 1912
SWEENY, F. R. I., Assistant Professor of Civil Engineering, Clemson Agricultural College, Clemson College, S. C. 1912

TENTATIVE PROGRAM FOR THE 1912 ANNUAL MEETING.

Tuesday morning—Business session, symposium on the teaching of physics led by Professors Franklin and McNutt.

Tuesday afternoon—Section meetings devoted to the discussion of the equipment for and conduct of engineering laboratories; the electrical engineers discussing their laboratories, the mechanical engineers discussing theirs, etc.

Tuesday evening—Annual dinner, president's address, and brief reception.

Wednesday morning—Symposium on the training of engineering teachers, led by Dean Anthony.

Wednesday afternoon—Continuation of section meetings on laboratories.

Wednesday evening—Business session, reports from section meetings and smoker.

Thursday morning—Symposium on efficiency in engineering instruction led by Mr. Gilbreth; election of officers, report of committee on resolutions, etc., closing the convention.

Thursday afternoon—Visits to the General Electric Works at Lynn, or elsewhere, at the pleasure of the members.

PERSONALIA.

Mr. Wm. S. Turner, of Portland, Oregon, an interested member of this society, has associated with him Messrs. John Reed and I. H. Sherwood, under the firm name of Wm. S. Turner and Co. The new arrangement took effect on January 1.

Professor J. W. Lawrence, of Colorado State Agricultural College, has been ordered by his physician to take a complete rest for a year. He has therefore taken a leave of absence and is now located at 2168 Dale St., San Diego, Cal.

After a temporary return to his duties at the University of Minnesota, Professor Arthur E. Haynes, has, after thirty-five years of continuous service, been obliged to give up his work permanently, his health not being equal to the demands upon it. At the urgent request of the editor, Professor Haynes has consented to the printing of the following poem which he composed to voice, for his friends, his present state of mind.

BECALMED.

No ripples stir the glassy depths,
  No breezes swell the drooping sail;
My ship lies sleeping on the deep,
  Waiting to wake when winds prevail.

The port I left, so long ago,
  Lies far below the ocean's rim;
The one I long for is unseen,
  The Lord's my Pilot; I'll trust Him.

He rules both wind and wave, as well,
  He knows the port my soul would win;
His breath will fill the idle sail,
  And there I'll anchor, safe with Him.

ARTHUR E. HAYNES.

December 26, 1911.

HENRY TAYLOR BOVEY, LL.D.

Professor Bovey died on February 2nd at Eastbourne, England, within a month of his sixtieth birthday anniversary. He was one of the charter members of this society having joined in 1893 when the Society was formed as an outgrowth of the congress held in connection with the Columbian Exposition. Dr. Bovey was a graduate of Cambridge University and after graduation practiced his profession of civil engineering in his native country. At the age of twenty-five he was appointed Professor of Civil Engineering at McGill University, Montreal, Canada, and remained at this institution for thirty-one years. A year after beginning this work he was made Dean of the Department of Applied Science of the University. Since 1908 Dr. Bovey has resided in London, where he has been rector of the Imperial College of Science and Technology.

JOHN BURKITT WEBB, C.E.

The attendants at the Pittsburgh meeting of the Society will remember Professor Webb's vigorous contribution to the discussion on engineering mathematics and at that time he seemed in prime health, although then seventy years of age. He died at Hoboken, N. J., on February 18. Professor Webb had a useful and varied career both in mathematics and in practical engineering. He received the degree of C.E. from the University of Michigan in 1870, where he was afterward an assistant for a year. Next he was Professor of Civil Engineering at the University of Illinois for seven years. He then went abroad for advanced study in mathematics and physics for three years. Of some of his experiences abroad and the results he told in an interesting manner at the Pittsburgh meeting. Returning to this country he taught mathematics at Cornell University for four years and at Stevens Institute for about twenty-two years. He resigned his position as professor a few years ago and took up consulting practice in Hoboken. Professor Webb has made a number of useful inventions and has written many important scientific papers.

THE SIX-YEAR COURSE IN ENGINEERING AT COLUMBIA UNIVERSITY.

BY PROFESSOR WM. H. BURR.

More than fifteen years ago the faculty of applied science of Columbia University set forth and recommended a complete course of engineering study extending over a period of six years and that course was approved and authorized by the trustees of the University. During this period of fifteen years or more a small number only of students annually have taken this course, although the marked educational excellence attained by those students has been clear.

Sufficient emphasis had not been laid upon this excellent curriculum until about a year ago when a committee of the faculty of applied science took up anew the consideration of the subject and revised the six-year course with subjects so selected as to bring the curriculum abreast of the present requirements of the engineering profession in all its fields. Beginning in 1914 this will be the only authorized and established course in engineering study at Columbia University.

The first three years' work will be taken chiefly in Columbia College as it covers essentially the educational work of the usual college course, with a few subjects only of a technical character, such as descriptive geometry, statics, and elementary surveying. The work in mathematics will be carried through calculus in this period. This college training is thus made to cover fully the work of the first year of the regular or ordinary four years' engineering course of study. On the successful completion of this three-year period of liberal educational work the Bachelor's degree will be conferred by the College and the candidate will then enter the professional engineering school.

There are seven courses of engineering study at Columbia

University for which the three years of preliminary college training, just described, is uniform, viz., mining engineering, metallurgical engineering, civil engineering, sanitary engineering, electrical engineering, mechanical engineering, and chemical engineering. The technical educational work to which the three years in the professional school are devoted covers probably a little more than is now taken in the last three years of the present four-year course. The student taking the six-year course of study will have the substantial advantage of the prior college training during which he will acquire the general or liberal educational discipline which engineers so much need but which up to the present is chiefly marked by its absence. It will probably be admitted by every engineering educator that such general preliminary educational discipline will enable the student in the professional school to benefit much more effectively by his training there than at present with a preparation markedly crude if not worse.

This change will place the engineering schools at Columbia on the same university plane as the schools of law and medicine and tend to make the engineering graduate both a properly educated man and a more effective member of his profession.

MATHEMATICS IN THE ENGINEERING CURRICULUM.

BY PROFESSOR B. L. NEWKIRK.

The abstract of Professor Riggs' paper* indicates a painful misapprehension regarding the science of mathematics. The author refers to it first as a tool and later uses the expressions "struggle in the mathematical gymnasium" "skin the cat of algebra" and "chin the pole of calculus." This would make the mathematician an artisan or an acrobat. Needless to say he is neither, but a scholar to whose contributions are due in large measure the achievements of the age. The engineer cannot build a bridge or a dam except upon the sure foundation of experience, organized and systematized into a sufficiently precise theory. The "educated common sense" and clear logical thinking that accomplish this organization constitute the science of mathematics in its application to engineering problems.

No one would claim that the few courses of mathematical instruction for which room can be found in an engineering course will develop a mathematical engineer. The college course does not develop engineers; it only gives their development a good start. More than this cannot be done for the man who is to serve the world in the capacity of a mathematical engineer. We can only teach a few of the more useful methods of attacking physical problems, acquaint the student with the functions most commonly employed, such as the logarithm and the trigonometric functions, and impart through proper drill some facility in certain special forms of reasoning essential to the mathematical method.

It is entirely proper to inquire whether even these introductory mathematical studies should be required of all engi-

* Bul. S. P. E. E., Vol. II, p. 248.

neering students, and whether failure in these subjects ought to bar a man from the engineering profession. A glance at any treatise on structural design, machine design, thermodynamics, electrical phenomena or almost any other subject fundamental to the engineering profession will show the tremendous difficulties that would confront one attempting to teach these subjects to persons unfamiliar with the elementary principles of mathematics. The results have been worked out by mathematical methods and they are explained in mathematical language. Indeed, they would be very much more difficult of comprehension if expressed in any other way. The easiest way by far is the mathematical way, otherwise it would have been discarded long ago. It is fair to presume then that the man who is unable to master the elementary mathematics would certainly be unable to master the physical theories which form the scientific basis of engineering practice. It is not for me to say whether a man may become a "big" engineer without a comprehension of the scientific fundamentals of the profession. It does seem clear, however, that the student who fails in the elementary mathematics must be denied entrance to courses in such fundamental subjects as those mentioned above. This bars the man from the training of an engineering college since the main courses are of this sort; and we must agree that it is proper that he should be so barred until some one shows us how to teach these subjects without mathematics or produces successful engineers without teaching them these fundamental branches.

SYLLABUS ON COMPLEX QUANTITIES.*

BY CHAS. O. GUNTHER, M.E.

Professor of Mathematics, Stevens Institute of Technology.

1. Derivation of formulæ:

$$e^{i\theta} = \cos\theta + i\sin\theta, \qquad e^{-i\theta} = \cos\theta - i\sin\theta,$$
$$\cos\theta = \frac{e^{i\theta} + e^{-i\theta}}{2}, \qquad i\sin\theta = \frac{e^{i\theta} - e^{-i\theta}}{2}.$$

2. Definition and graphical representation of a complex quantity. Polar trigonometric and polar exponential equivalents of $z = x + iy$, that is,

$$z = \rho(\cos\theta + i\sin\theta), \quad \text{polar trigonometric;}$$
$$z = \rho e^{i\theta}, \quad \text{polar exponential;}$$

in which $\rho = \sqrt{x^2 + y^2}$ is the *modulus* (the positive sign being always associated with it); and θ, given by the relation $\tan\theta = y/x$, is the *argument* of z. Any multiple of 2π may be added to the argument without altering the complex quantity.

3. Graphical addition, subtraction, multiplication and division of complex quantities. Graphical solution of the equation $x^n \pm 1 = 0$. Logarithms of complex quantities.

Applications to Integration.

4. The expression

$$dy = \tan^{2p}\theta \sec^{2r+1}\theta d\theta,$$

in which p and r are positive integers or zero, is by the substi-

* This syllabus was prepared as an appendix to the report of the Committee on the Teaching of Mathematics to Engineering Students at the request of the members of the Society present at the Pittsburgh meeting.

tution $\tan\theta = i\sin\alpha$ (α being an imaginary quantity) transformed into

$$dy = i(-1)^p \sin^{2p}\alpha \cos^{2r}\alpha d\alpha.$$

This latter expression can be integrated by doubling α as many times as necessary.

The foregoing includes the integration of the expression

$$dy = \cot^{2p}\theta \csc^{2r+1}\theta d\theta,$$

since the latter expression may be written

$$dy = -\tan^{2p}\left(\frac{\pi}{2} - \theta\right)\sec^{2r+1}\left(\frac{\pi}{2} - \theta\right)d\left(\frac{\pi}{2} - \theta\right).$$

As found in text-books, the integration of the expression

$$dy = \cos^h\theta \sin^k\theta d\theta \qquad (1)$$

is readily accomplished in three cases, namely:

(a) When either h or k is an odd positive integer.

(b) When $h + k$ is an even negative integer.

(c) When both h and k are even positive integers, or zero.

The first two of these cases include *fractional* values for h and k.

By means of the substitution given above, all the other cases in which h and k are integers can be brought under one or more of the three cases just mentioned.

In the above are also included all the cases for which the general binomial differential expression

$$dy = x^m(a + bx^n)^{p/q}dx$$

can be integrated without resorting to infinite series. This expression is only another form of (1), since $\sqrt{a + bx^n}$ can always be represented by one of the three sides of a right triangle and therefore expressed as a trigonometric function of one of the acute angles of the triangle.

In determining the value of a definite integral, if the variable is changed the limits should be changed to correspond. For example, in finding the length of the arc of the parabola,

$y^2 = 4ax$, from the vertex to the point $(a, 2a)$, we have

$$S = \frac{1}{2a}\int_0^{2a} \sqrt{4a^2 + y^2}\, dy$$

$$= 2a \int_{\tan\theta=0}^{\tan\theta=1} \sec^3\theta\, d\theta$$

$$= 2ai \int_{i\sin\alpha=0}^{i\sin\alpha=1} \cos^2\alpha\, d\alpha = ai \int_{i\sin\alpha=0}^{i\sin\alpha=1} (1 + \cos 2a) d\alpha$$

$$= a \log_e (\cos\alpha + i\sin\alpha) + ai \sin\alpha\cos\alpha + C \Big]_{i\sin\alpha=0}^{i\sin\alpha=1}$$

$$= a\,[\log_e (\sqrt{2} + 1) + \sqrt{2}].$$

Further applications of complex quantities to integration will be found in my discussion.

THE AMERICAN MINING CONGRESS AND THE PROMOTION OF MINING ENGINEERING EDUCATION.

BY F. W. SPERR,

Professor of Civil and Mining Engineering, Michigan College of Mines.

The fourteenth annual meeting of the American Mining Congress was held in Chicago, October 24 to 28, 1911. The scope of the work undertaken by the Congress is well represented by the resolutions adopted at the closing business session. Thirty-five different States were represented on the committee on resolutions: Alabama, Arkansas, California, Canada, Colorado, Georgia, Idaho, Indiana, Illinois, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Montana, Nebraska, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, South Dakota, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, and Wyoming. The following States are also more or less interested in the development of their mineral resources, but they do not appear to have been represented: Arizona, Connecticut, Florida, Maine, Maryland, Massachusetts, Nevada, New Hampshire, Rhode Island, Tennessee, and Vermont.

The resolutions reported by the committee and adopted by the Congress were twelve in number. The first memorialized the Congress of the United States to provide for the establishment of experimental ore-testing stations. The second is here given in full, because it is the one with which this paper has most to do:

"In view of the increasing importance and complexity of the mining and metallurgical industries, the deplorable waste in mining under present methods, and great need of trained men to aid in improving these conditions and in developing greater safety and efficiency; be it

"*Resolved,* That the American Mining Congress now in session at Chicago urges the Congress of the United States at Washington to provide for aid and coöperation in the maintenance of mining schools in the several States in a manner analogous to that which has been done in behalf of agriculture. Be it

"Resolved, That the members of the American Mining Congress and the friends of the mining industry throughout the country are hereby urged to coöperate in securing the proper legislation necessary to carry above purpose into effect."

A bill to provide aid to mining schools was introduced in the House of Representatives, by Mr. Foster, of Illinois, April 20, 1911. Mr. Foster is a sincere and active friend of all mining interests; and his bill has received the endorsement of many of the schools and departments of mines and mining which are intended to be its beneficiaries. The friends of this bill who attended the meeting of the Mining Congress, were active in securing the adoption of the above resolution. On account of delay in securing a copy of the bill, it has been impossible to prepare this matter for an earlier issue of the BULLETIN. But its discussion may still be of interest to some of the members of our Society. It reads as follows:

62D CONGRESS, 1ST SESSION. H. R. 6304.

IN THE HOUSE OF REPRESENTATIVES

APRIL 20, 1911.

Mr. Foster of Illinois introduced the following bill; which was referred to the Committee on Mines and Mining and ordered to be printed.

A BILL

To apply a portion of the proceeds of the sales of public lands to the endowment of schools or departments of mines and mining, and to regulate the expenditure thereof.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there shall be appropriated from the sale of public lands, not otherwise appropriated, the sum of five thousand dollars for the fiscal year beginning July first, nineteen hundred and eleven; the sum of ten thousand dollars for the fiscal year beginning July first, nineteen hundred and twelve; the

sum of fifteen thousand dollars for the fiscal year beginning July first, nineteen hundred and thirteen; the sum of twenty thousand dollars for the fiscal year beginning July first, nineteen hundred and fourteen; the sum of twenty-five thousand dollars for the fiscal year beginning July first, nineteen hundred and fifteen, and twenty-five thousand dollars for each succeeding year thereafter, to each State and Territory in the United States, for the establishment and maintenance, under the control of the Secretary of the Interior of the United States, of a school or department of instruction in mines and mining.

SEC. 2. That if there be already established in any State or Territory a school of mines and mining under the control of said State or Territory, or a department of instruction in mining connected with any institution of learning controlled by said State or Territory, then the moneys appropriated in section one of this Act shall go to said school or department of instruction already established. That if there are two schools or departments of mines and mining in any State or Territory under the control of said State or Territory, then the money so appropriated shall be equally divided between such schools or departments. That if there be no school or department of instruction in mines and mining already established in any State or Territory, the school or department of instruction in mines and mining herein provided for shall be established in connection with an agricultural college, if there be such, controlled by said State or Territory. In States and Territories having no school or department of instruction in mines and mining already established or agricultural college, then the Secretary of the Interior shall designate some other institution of learning controlled by said State or Territory, in connection with which said school or department of instruction in mines and mining shall be established: *Provided*, That if any State or Territory have no school or department of instruction in mines or mining, or agricultural college, or other institution of learning controlled by said State or Territory, then the Secretary of the Interior shall designate some accessible and convenient place in said State or Territory where the school of mines and mining herein provided for shall be located.

SEC. 3. That the money appropriated in section one hereof shall be expended only for instruction, research, and experiment (including the employment of instructors and experts, the purchasing of apparatus, supplies, books, and the equipping of laboratories) in mining, mining machinery (with the application of electricity thereto), mining engineering, ore treatment, metallurgy, assaying, and chemistry and geology, so far as these sciences relate to minerals and mining, with a view to teaching a practical and scientific knowledge of the best and safest methods of mining and carrying on the business of mining and of producing gold, silver, coal, and other minerals, oil, gas, and medicinal

waters, and also the concentrating, smelting, refining, and other preparation of the same for marketing, so far as the same may be necessary and appropriate to the mineral resources of the State or Territory in which said school or department of instruction in mines and mining shall be located; and especially for the study and prevention of explosions, fires, and other dangers incident to the carrying on of mining and the mining industry, in order to secure the most intelligent conservation, use, and development of the mining and mineral resources of the country, to make the lives of miners more safe, property in mines more secure, and to promote the general welfare of miners and operators of mines.

SEC. 4. That the head of each school or department of instruction in mines and mining established according to this Act shall report in writing annually, on or before the first day of July, to the governor of the State or Territory in which said school or department of instruction is located, the condition, progress, and work of the school or department of instruction during the year past, together with such recommendations as he may deem best for accomplishing the purposes of this Act as set forth in section three hereof; and that a copy of said report shall be also sent to the Secretary of the Interior.

SEC. 5. That if at any time in the judgment of the Secretary of the Interior any school or department of instruction in mines and mining provided for in this Act shall not be faithfully carrying out the purposes of said Act as set forth in section three hereof, then all moneys herein appropriated for said school or department of instruction shall be withdrawn from said school or department of instruction until the same shall have produced evidence satisfactory to the Secretary of the Interior that said school or department of instruction is faithfully carrying out the provisions of section three of this Act.

SEC. 6. That the sums hereby appropriated to the several States and Territories for the purpose herein specified shall be annually paid, on or before the thirty-first day of July of each year, by the Secretary of the Treasury, upon the warrant of the Secretary of the Interior, out of the Treasury of the United States, to the State or Territorial treasurer or to such officer of each State or Territory as shall be designated by law to receive the same, who shall, upon the order of the trustees or other board of control of said college or university or separate school of mines, immediately pay over said sum to the respective treasurers of such institutions or to such other officers as may be duly authorized by said trustees or board of control to receive the same.

It would appear that the above bill should receive some modifications before it becomes the law. Section 2 provides that if there are two schools or departments of mines and

mining in any State or Territory under the control of said State or Territory, then the money so appropriated shall be equally divided between such schools or departments. But why limit the number to two? Why not give every school under the control of the State or Territory, the opportunity to establish a mining department in order to secure a portion of this money? Why only two? Judging from the past experiences in some of the States over Government appropriations, a lively scramble may be expected over the provisions of this section. It further provides that if there be no school or department of instruction in mines and mining already established in any State or Territory, the school or department of instruction in mines and mining herein provided for shall be established in connection with an agricultural college, if there be such, controlled by said State or Territory. Imagine the agricultural colleges in some of our states where there are now no mining schools, devoting their energies to the development of the mining industries of those states! No doubt all the schools could use the money to good advantage if they were not required to expend it for some specified object in which they are not interested. Then, if there is no school or department of mines and mining already established, or agricultural college, the bill provides that the department of mines and mining shall be established in connection with some other institution of learning controlled by the State or Territory. Would the normal schools come next after the agricultural colleges? Could not the schools for the blind and for the feeble-minded come in their proper order for claims to the right of establishing departments of mines and mining? And if there is no "institution of learning" controlled by the State or Territory, the Secretary of the Interior shall designate some accessible and convenient place in said State or Territory where the school of mines and mining herein provided for shall be located. Is this intended to meet the probable claims of Alaska?

Section 3 appears to provide with equal care that no interest

shall be left out from the benefits of the bill. Even the exploiters of mineral waters seem to be provided for. Then, verily, it should not be difficult for any school or department of mines and mining provided for in this Act to be found at all times faithfully carrying out the purpose of said Act as set forth in section three; and thus remain secure against the possible withdrawal of the money by the Secretary of the Interior, under the provisions of Section 5.

Is it possible that this bill, as it stands, can pass the House of Representatives and the Senate, and receive the signature of the President of the United States? It will probably not receive the support of all the mining schools, nor of any considerable portion of the mining industry. Would it not be better to provide that the money appropriated should go to such schools or departments of mines and mining as were already established under State control at the time the first bill was introduced in the Congress of the United States, for federal aid to mining schools? For, unless some limit of time is set for the establishment of such schools or departments, there is abundant experience and evidence to indicate that much trouble will follow, and much of the money will be unwisely expended. And in case there were no such schools at the time specified, would it not be better to leave the matter at the discretion of the Secretary of the Interior as to whether the money shall go to the State or Territorial Geological Survey, to the United States Bureau of Mines, or to a new school to be established under his direction? Would not such provisions better insure the expenditure of the money for the development of the mineral resources and for the welfare of the mining industry?

The other ten resolutions of the Mining Congress related to inland waterway projects which were favored; to the destructive method of coal mining known as "shooting off the solid," which was condemned; to compensation for injured working men, favored; to unscrupulous mine promoters, condemned; to publicity committee, recommended; to National Parks on

public mineral lands, disapproved; to the Bureau of Mines, thanking the President and Congress of the United States for its creation; to the death of Geo. E. W. Dorsey, paying high tribute to his character and expression of sympathy to his family and friends; to Alaska coal mines, asking the Congress of the United States at its approaching session to enact such legislation as will bring about the opening up and operation of these mines; and finally a resolution of thanks for kindly treatment received from the city of Chicago, the state of Illinois, the trade journals and the general press.

The subject of the Alaska coal lands was discussed most thoroughly and created liveliest interest on the part of those who attended the meeting. The operation of the Alaska coal mines should be kept under the supervision and control of United States Government engineers. The history of coal mining in the state of Ohio furnishes an interesting case in point. Twenty-five or thirty years ago, the extraction of coal from the mines in the Ohio field was only from 30 to 40 per cent. About that time, Mr. W. H. Jennings, chief engineer of the Hocking Valley Railroad, undertook to bring about a higher percentage of extraction by the operators on lands leased from the railroad company. Mr. Jennings by means of properly drawn contracts and a methodical system of surveys and inspections, in a few years succeeded in raising the percentage of extraction to 90 and over. Just before the panic of 1893, there were quite a number of coal mine operators on other lands as well, who were ambitious to secure at least 90 per cent. extraction. But the panic seems to have changed all this. The conditions seem to have gone back towards what they were before Mr. Jennings's time. It seems that coal lands are too plentiful and the fee-owners too anxious to lease on any conditions that will bring in some royalty on which they may live.

It would seem the part of wisdom on the part of the people of the United States to keep their Alaska coal lands as an asset until such time as there shall be an actual demand for

the coal. From all past experience it is evident that most of the coal will be wasted and destroyed if it is mined under private ownership. Leases might at first be given with no other requirement than that the extraction should be the best possible and to the satisfaction of the Government surveyor and inspector.

COLLEGE NEWS.

University of Arkansas.—Plans are being perfected for the Peabody Educational Building which is to be erected on the campus at a cost of $40,000.00. This building is to be occupied by the department of philosophy and pedagogy.—Professor J. H. Reynolds, of the department of history and political science, will return about April first from Oxford, England, where he has been spending the winter at the University.

Carnegie Technical Schools.—Mr. R. M. H. Robinson, naval instructor, U. S. N., lectured to the engineering students February 8 and 15 on "Battle-Ship Construction." A large model of the *North Dakota* was loaned by the government and shipped from Washington to Pittsburgh for the purpose of illustrating the lectures.—In accordance with a recent action of the board of trustees entrance scholarships will be awarded in 1912 to a limited number of qualified students, each scholarship amounting to $100 in cash and free tuition.—Professor Horace R. Thayer, of the civil engineering department, has a book on the "Elements of Structural Design" in the hands of the publishers.—Mr. A. L. Humphrys, vice-president of the Westinghouse Air Brake Co., was the speaker for the evening at a recent meeting of the combined engineering societies of Carnegie. He talked on the "Human Element of Engineering."—A life-size bronze bust of Andrew Carnegie, the work of the Chicago sculptor J. Massey Rhind, was unveiled with appropriate exercises on January 25. The donors were Judge and Mrs. James H. Reed of Pittsburgh.—On request from a group of graduates of various engineering schools, who hold positions in the works of the Carnegie Steel Company, a class in rolling-mill design was started in the Night School of Applied Science at the beginning of the second semester, February 1.—The senior class in the School of Applied Science recently adopted the honor system. Following this action, the faculty ruled that no record of attendance is to be taken in the senior class during the second semester.—On invitation from the Erie, Pa., Chamber of Commerce, Secretary Field, of the Schools, recently investigated the educational situation in Erie, preliminary to making suggestions for the proposed establishment of a school for manual and industrial training.

Colorado School of Mines.—A course in applied chemistry will be added at the Colorado School of Mines. The heavy work in chemistry required in the metallurgical course which the school has been giving for years has caused the development of a very strong chemical depart-

ment with excellent apparatus and laboratories. It is therefore with very little added expense that the complete course in chemistry can be given and the graduates will meet a constantly increasing demand.—$12,500.00 was recently turned over to the authorities of the Colorado School of Mines for the equipment of the new ore testing plant. The building for the plant was built a year ago and $50,000.00 was allowed by the legislature for the necessary machinery and one fourth of this is what is now available. Many donations of machinery have been made by the various manufacturers and it will now be possible to completely equip, ready for operation, the concentration section of the plant. Professor W. Y. Haldane will be in direct charge of the work.

Columbia University.—In connection with the graduate course in highway engineering at Columbia University the following illustrated lectures were given during the month of February by non-resident lecturers in highway engineering: February 9, "Contracts and Specifications," Harold Parker, vice-president and manager, The Hassam Paving Company, Worcester; February 16, "Trinidad and Bermudez Asphalts and Their Use in Highway Construction," Clifford Richardson, consulting engineer, New York City; February 19, "The Design of Highways and Systems of Highways," Nelson P. Lewis, chief engineer, Board of Estimate and Apportionment, New York City; February 23, "Inspection of Sheet Asphalt Pavements," A. W. Dow, chemical and consulting paving engineer, New York City; February 26, "Technical Literature," John M. Goodell, editor-in-chief, *Engineering Record.*

University of Illinois.—Calvin W. Rice, secretary of the American Society of Mechanical Engineers, was the guest of the student branch of the Society in the College of Engineering of the University of Illinois on January 23 and 24. In an address before the members of the Society, Mr. Rice emphasized the importance of every engineer being interested in the national engineering societies. Mr. Rice was entertained by the local members of the Society at a dinner at the University Club in the evening of the 23d.—The annual meeting of the Illinois Society of Engineers and Surveyors for 1912 was held at the University of Illinois on January 17, 18 and 19. The program was of unusual excellence. The more important engineering topics discussed were Stream Pollution, Sewage Disposal, Accuracy in Surveying, Road and Pavement Problems, and the Bridge Work of the Illinois Highway Commission. Two illustrated lectures of great interest were given, one by Professor I. O. Baker on the Panama Canal, and one by Mr. H. L. Cooper, chief engineer, on the Keokuk Water Power Plant. An afternoon was spent in inspecting the buildings and discussing the work of the College of Engineering.—Mr. H. M. Byllesby, president of the H. M. Byllesby Company, gave an address before the students and faculty of the Col-

lege of Engineering of the University of Illinois on Thursday, January 18. His subject was "Organization in Engineering."—Another recent speaker was Mr. C. A. Seley, mechanical engineer of the Rock Island Lines, who spoke on "Conference Committee Methods in Handling Railway Legislation on Mechanical Matters."

State University of Iowa.—Professor G. W. Stewart has been named by President Taft to be a member of the National Assay Commission, which met on February 14, in Philadelphia, to pass upon the purity and quantity of metal in the gold and silver coins of the United States.

University of Kansas.—New faculty appointments this year: Chas. I. Corp returns after a year of graduate work at the University of Wisconsin as associate professor of mechanical engineering in charge of hydraulics. W. A. Whitaker becomes associate professor of metallurgy. D. W. Stradling takes the work in railway engineering in the absence of Associate Professor J. B. Dalton, who is engaged in the work of physical valuation of railroads for the State Utilities Commission. O. W. Melin is instructor in civil engineering, C. A Haskins is instructor in municipal engineering, H. E. Jordan, J. O. Hassler, and J. J. Wheeler are new men in the mathematics department, and R. R. Fisher is assistant instructor in mechanical engineering.—Prof. G. F. Swain, of Harvard University, lectured at the University recently in the interests of the Sigma Xi Society, on the subjects, "Failure of the Quebec Bridge" and "Conservation of Forests as Affecting Stream Flow."—Mr. Calvin W. Rice, secretary of the American Society of Mechanical Engineering, also visited the University recently.—During the first two weeks of December most of the senior electrical and mechanical engineers were engaged on an extensive test of the new power plant of the Wichita Edison Co., conducted by the owners and builders jointly. The students were in the direct charge of C. A. Johnson and R. R. Fisher, of the faculty.

University of Minnesota.—Dean Shenehon, of the College of Engineering, was called to Niagara Falls to consult with the Hydraulic Power Company of that place with respect to remedial works in the Niagara River to permit greater diversion of the river water for power purposes without destroying the scenic grandeur of Niagara Falls. He was in Niagara Falls for one week designing a compensating weir, and then went to Washington to appear before the Committee on Foreign Relations of the House of Representatives. He took advantage of his presence in Washington to consult with Representatives Nye and Stevens with regard to the High Dam in the Mississippi River.

University of North Carolina.—The last Legislature gave the University for building purposes the sum of two hundred thousand dollars. The first building to be erected is the new Medical School, now nearing

completion; the next building will be a dormitory, now in course of erection, and then will come a new building for physics, electrical engineering, and civil engineering, to cost $50,000.—Dr. Albert R. Ledoux, of New York, formerly residing here as State Chemist, has given the sum of $5,000 for the establishment of a fellowship in chemistry. This is the third fellowship in chemistry to be established since 1905.—The Peabody Education Board has given the University $40,000 with which to erect a new building for the School of Education. It is hoped to have this building ready for occupancy in September next.—Owing to the resignation as Dean of Dr. Charles H. Herty, professor of chemistry, the trustees have elected Professor Andrew H. Patterson, of the chair of physics, dean of the School of Applied Science.—Mr. W. H. Fry, instructor in geology, has resigned to accept the position of mineralogist and petrographer of the Bureau of Soils in Washington.—Dr. Archibald Henderson, professor of mathematics, and Dr. Alvin S. Wheeler, associate professor of organic chemistry, are back at work here after a year's leave in Europe.—Professor T. F. Hickerson, associate professor of civil engineering, has a leave of absence which he will spend at Columbia University, studying highway engineering.—Dr. Robert A. Hall has been apointed instructor in chemistry, in place of Mr. Hampden Hill, resigned. —The enrollment of the University to date is 785. Of these 23 are studying chemical engineering, 28 electrical engineering and 24 civil engineering, in the regular courses leading to degrees.—The McNair lectures, which were delivered by Dr. David Starr Jordan in 1910, and by Dr. Henry van Dyke in 1911, will this session be given by President Arthur T. Hadley, of Yale.

Oklahoma A. and M. College.—Two new buildings are now under construction on the college campus. One of these is an auditorium with a seating capacity of 1,800. The other, of reinforced concrete, is the engineering building, which is to contain the four departments of mechanical, electrical, civil and architectural engineering. The first floor contains the laboratories, the second floor the class rooms and offices, and the third floor the drawing rooms. The cost of the two buildings is $170,000.—Professor Frederic C. Biggin, formerly of the faculty of Lehigh University, and for several years a practicing architect of Atlanta, Georgia, has recently taken charge of the department of architectural engineering.

Pennsylvania State College.—The electrical department has received a specially-designed harmonic set, consisting of three 3-phase alternators, the fields of the three machines being mounted on the same shaft. The largest of these generators is for 60 cycles, the second for 180 cycles and the third for 300 cycles. The pressure waves developed by all three machines, or by any two of them, may be superposed, and the waves

themselves may be displaced by any desired amount. The harmonic set, in connection with a three-element oscillograph provides equipment for exhaustive study along certain lines of alternating current theory. It is the second of its kind that has been manufactured, the first being in the possession of the Electrical Testing Laboratory in New York City. This apparatus was purchased primarily to permit Professor C. L. Kinsloe to continue his experiments on incandescent filaments. The first part of his investigation was published in a bulletin of the Engineering Experiment Station of Pennsylvania, which is located at State College.—A 200-ft. steel tower for wireless work is under construction. It will be used in connection with a 5 k.w. set to be located in a small brick building. Mr. N. H. Slaughter is in charge of the work.—Dean Jackson has this year vigorously inaugurated the policy of character training throughout all the technical classes in his school. Every two weeks at the faculty meetings the subject is considered and reports are made by instructors concerning the measure of success they have attained and the methods adopted. The experience thus far warrants the belief that a very positive and valuable adjunct to the ordinary technical education is being developed which should prove of large value in developing the characteristics most needed by the students for success in the engineering profession and useful citizenship.—Professor A. H. Gill has resigned to enter industrial work. Professor J. P. Calderwood has been assigned charge of the experimental laboratories in his place, and Mr. R. M. Pennock takes Professor Calderwood's classes in heat engineering.—Mr. H. M. Glazier, instructor in architectural engineering, has resigned to take up architectural work in Cleveland, Ohio.

University of Pittsburgh.—Professor Reid T. Stewart, head of the department of mechanical engineering, was recently retained by the National Tube Company to prepare its new book of tables. This will contain a large amount of original data which has been secured from a long series of experiments carried on at the University of Pittsburgh.—The department of English in the University is reorganizing the work in the School of Engineering with the idea of making it more interesting and profitable to the students. This will include the reading and criticism of technical papers adapted to the needs of the students. The department will also pay particular atention to public speaking, especially with reference to the presentation of papers and reports.—Dr. M. J. Rosenau, professor of preventive medicine and hygiene at the Harvard Medical School, gave the second public lecture on sanitary engineering in Thaw Hall on the evening of January 23. The subject of his lecture was "The Ounce of Prevention." The next lecture in this series will be given by Professor C. E. Winslow, of the College of the City of New York.—The following men have recently lectured before the students in the School of Engineering:

Lecturer.	Subject.
Col. Thos. P. Roberts, government engineer in Pittsburgh.	Work of the U. S. Government on the Improvement of the Rivers of this District.
Professor P. M. Lincoln, head dept. electrical engineering.	Some Recent Developments in Electrical Engineering.
Professor Robert Kennedy Duncan, head of the dept. of industrial research at the University.	Some Problems for the Chemical Engineer.
Mr. S. M. Kintner, gen. mgr., National Electric Signaling Co.	Wireless Telegraphy.
Emil B. Guenther, mechanical engineer with the Westinghouse Machine Co.	Gas Producers.
Dr. W. W. Strong, special research fellow on smoke prevention, University of Pittsburgh.	Smoke Prevention.

Pratt Institute, Brooklyn, N. Y.—Two graduates of Pratt Institute have recently been appointed instructors in the Escola de Engenharia of Porto Alegre, Brazil, Mr. Charles F. Dreyer, 1908, as chief of the department of applied science in the Instituto Technico Professional of this institution and Mr. Thomas A. Smith, 1907, as chief of the department of machine work. Both of the appointees are graduates of the steam machine design course of the School of Science and Technology, Pratt Institute, another of whose graduates, Mr. Harry Rees, has for two years occupied the position of chief of the department of applied electricity in the Escola de Engenharia.

Purdue University.—President Charles S. Howe, of the Case School of Applied Science, was the guest of the University during the week of January 15. On Monday, he gave an illustrated lecture before the engineering assembly on "Our Nearest Celestial Neighbor," otherwise the moon. Many of the slides shown were from recent photographs obtained by the observers at the Lick and Yerkes observatories and also from the new Harvard Observatory in Jamaica. On Tuesday evening, President Howe was the guest of the University Club, taking part in a reception and giving an address on "Some of the Needs of a Modern City." Dr. Howe's intimate connection with various municipal activities in Cleveland gave him a good store of material from which to draw. On Wednesday, he addressed the student convocation, taking for his subject "Success for the College Graduate."—The engineering assembly on Monday, January 22, was addressed by Mr. A. H. Sabin, consulting chemist of the National Lead Company, who gave an illustrated lecture on "The Manufacture of White Lead."—The University has just ad-

vertised for bids on a new library building to be erected the coming season. The building will be of Bedford stone and gray brick with a tile roof, and have a ground area of 120 by 90 feet. Patton and Miller of Chicago are the architects. The structure will be of the renaissance type, having the main reading room, 116 by 40 feet, on the second floor. This will be approached by a wide marble stairway. An auditorium and a large study room will be located on the first floor. The building is to be located east of Fowler Hall, fronting on State Street.—Fifty thousand dollars of the bequest from the late Mr. W. C. Smith has been appropriated by the trustees for the construction of a new dairy building. The housing of the dairy department at present is entirely inadequate, being in the basement of Agricultural Hall, a place not at all suitable for work of this character. The money now available will make it possible to build and equip a modern structure in accordance with the best practice.

The University of Texas.—Dr. N. H. Brown, a graduate of Cornell University, was elected professor of electrical engineering in June, 1911, and reported for duty September 15, 1911. Dr. Brown is not unknown to Texans, as he was connected with the Agricultural and Mechanical College of Texas for several years as professor of electrical engineering. —James A. Correll, a graduate of M. I. T., and H. C. Weaver, a graduate of the University of Michigan, received substantial promotions in June as instructors in electrical engineering.—In the School of Civil Engineering Professor Bantel and Instructors S. P. Finch and R. G. Tyler were promoted in rank and salary at the meeting of the Board of Regents in June, 1911. Mr. Tyler resigned on January 1, 1912, to accept the position of principal assistant engineer with the State Drainage Commission. Mr. L. C. Wagner, C.E., University of Texas, a former instructor in civil engineering, has been appointed to fill out Mr. Tyler's unexpired term.—The engineering faculty has just made a unanimous recommendation to the general faculty of the University to the effect that a five-year course be prescribed for the professional engineering degree and that the degree of Bachelor of Science be awarded at the end of four years.—In December Dr. J. A. L. Waddell lectured upon "The Ethics of Bridge Engineering" and "Deep Foundations," before the engineering students.

Yale University.—The following lectures have recently been given by men who are not members of the faculty: In electrical engineering, one on "The Electrification of the Long Island R. R.," by O. S. Lyford, Jr., electrical engineer for Westinghouse, Kerr and Co., and one on "Practical Applications of the Induction Motor," by C. R. Beardsley, of New Haven, Conn. In mechanical engineering, one on "The Cost of Power," by Dean Benjamin, of Purdue University, and another on "The Pre-

vention of Accidents in Factory and Shop," by Professor F. R. Hutton. In mining engineering, one on "Mining Practice in South Africa," by T. Lane Carter, one on "The Preparation of Coal," by Mr. E. B. Wilson, editor of *Mines and Minerals*, another on "Electrolytic Refining of Copper," by Professor A. L. Walker, of Columbia University, and one on "Observations of Western Copper Mines," by W. R. Ingalls, editor of *Engineering and Mining Journal*. In civil engineering, eight on "Contracts and Specifications," by Professor R. S. Kirby, of Gettysburg, Pa.

ENGLISH IN ENGINEERING SCHOOLS.*

As delegate for 1911–12 from the Engineering School of Tufts College, appointed to study the subject of English in technical schools, I visited in December the following: Carnegie Technical Schools, Case School, Columbia University, Cornell University, Ohio State University, Sheffield Scientific School, Stevens Institute, University of Cincinnati, University of Michigan, University of Pennsylvania, University of Pittsburgh, and University of Wisconsin. In most of the schools changes in curriculum were under consideration or had been recently adopted which are important not only in themselves but in their bearing on the teaching of English.

To understand the situation, it is necessary to recall something of the past development. When courses in engineering were first given, there was little which could be taught and that little was of decidedly elementary character; consequently the students had opportunity, in class and out, to gain much in the way of general education. Since that time engineering has come to include a great variety of special sciences. All eyes have been on the experts. As a result there has been during these years strong pressure to introduce as much as possible of this special work in schools, and to graduate men who were abreast of the times in at least one narrow field. Along with this, there has been a growing tendency to give students training in the actual practice of the profession they were to enter. This has meant a steady process of squeezing out the general education. That there has been serious loss is now generally recognized; and the problem at present, most schools seem to feel, is to recover as much as possible of that loss. Some favor a five-year, some a six-year course. Some would admit to the engineering school only mature men

* Abstract of a report presented by S. C. Earle, professor of English, to the faculty of the Engineering School, Tufts College, January 16, 1912.

who have had full collegiate training; others believe that more than four years' study beyond the secondary school unfits most men for professional work. In other words, different methods are advocated in different* schools; but they all tend to one end: everywhere I found a definite purpose to strive for better fundamental training and especially a determination not to allow advanced and specialized work to squeeze out general education.

In a similar way, I found a strong reaction against the tendency to emphasize the teaching in school of engineering practice. Employers have been slow to recognize their responsibilities; they have too generally assumed that it was the business of engineering schools to prepare students to handle any special problem assigned them, according to the best practice. I found, however, that men of the widest experience felt that commercial concerns are generally coming to realize that they too have a part in the process of education; and in colleges, it seems to be more and more clearly recognized that it is the business of the schools to teach the fundamental principles—the theory—and that it is equally the business of the commercial concerns to teach the practice.

In whatever way the attempt is made to give more solid grounding in the fundamentals and to give a broader general education, it is recognized in all the schools that special attention should be paid to work in English; that is to say, to training in oral and in written expression and to the study of literature.

English is required in all the schools except two, but it stands in different relations to the major departments. Three institutions, being simply technical schools, have their own departments of English. Three which are parts of universities make use of teachers of English in the associated college

* The interviews on which the report is based were in many cases confidential, consequently no reference to individual teachers or to individual schools is made in this published abstract. The purpose of the investigation, it should be noted, was not to make a comparative study, but simply to get suggestions.

of letters, but in each of these cases the teachers are delegated to the engineering school and give separate and specialized instruction. In four of the universities there is no special instruction in English for engineers. In two of these, such instruction is to be given, however, as soon as "properly fitted" teachers can be found; and in the other two, though specialized work has not the approval of the heads of the English departments, it is strongly favored by those in charge of the engineering courses. It was almost universally recognized that students of engineering take more interest in English and show much better results when taught separately and by instructors who are in full sympathy with the course in engineering.

In all the schools, I found a keen appreciation of the importance for engineers of good training in English, an appreciation which has been growing of late years. Of the two schools that require no English, one has for years acted on the theory that the study of engineering should be preceded by a full collegiate course, a theory which it is now prepared to put into practice; the other has special entrance requirements in English which serve to turn away those weak in the subject and to hold up to a higher standard all who intend to enter. In addition this latter school does much effective work in English which does not appear in the curriculum, in the written work in connection with technical subjects and in the development of appreciation of good literature.

Along with the appreciation of the value of good training in English, I found everywhere on the part of teachers of engineering a recognition that the schools have not accomplished what they ought in teaching this subject. It is even said in several places that the younger technical instructors themselves show notably poor training in English. Everyone concerned is eager to get suggestions which may lead to better results.

In all the schools, except the two noted, English is required during the freshman year and to some extent during the sopho-

more year.* In four schools at least, the intention is to increase the requirement.

Of the few teachers of English I met who do not think special instruction for engineers is necessary, none I believe are in direct charge of classes of engineers. Those who teach engineers are enthusiastic over their special work. They recognize that there are excellent educational opportunities in the technical uses of English; and, more than that, they feel strongly that it is not good judgment to drill a student a few hours a week in writing on subjects in which he may not be interested, and allow him during all the rest of the time to express himself on subjects in which he is interested or immediately concerned, without directions or assistance. In fact the technical work offers so many opportunities that in a number of instances teachers of English are making a thorough study of many important parts of the engineer's work: going with classes on inspection trips, working with technical instructors, studying certain branches of law that they may teach the writing of contracts, collecting and studying engineering reports and letters of all sorts, and learning library methods of making bibliographies and indexes. In some places, they are giving courses in logic; in some, elaborate courses in public speaking.

The present position of most teachers of English in technical schools, I was surprised to find, is quite unsatisfactory. It has improved of late in one way, as a result of the general recognition of the importance of the work. In some cases I was told that not long ago the work was not only slighted by the students but was not supported by the faculty, many of whom were ready to have it abandoned entirely. All that has improved because of the change in the general attitude of engineers toward the subject. In fact schools at present are demanding a great deal of their teachers of English, and the teachers generally are not only eager to meet the heavy responsibilities put upon them, but are continually on the lookout for new ways to accomplish more and more. But the

* Information which may be obtained from catalogues is omitted here.

result is that the teachers find themselves buried under routine and compelled in a large part of their work to smatter. Furthermore, since both the departments of English and the departments of engineering can disclaim responsibility for them, they are, in most cases, without due recognition in the way of grade or salary. Of three of the ablest I met, one is an assistant-professor (with the pay of an instructor), and the other two are instructors; and no one of them has any prospects at present.

In conclusion I will give, for what they are worth, a few suggestions as to ways of improving the situation, which are, so to speak, composites of ideas expressed by many teachers.

In a number of places I was asked how to get men properly trained for this important work. It seems to me evident that as conditions are at present both men with good training in engineering and men with good training in English can find much better opportunities than are offered to teachers of English in technical schools; consequently few men of the right character and training will be willing to continue in this work till greater inducements in the way of grade and of salary are offered.

The amount which the teacher of English attempts to do should be lessened in two ways:

1. He should learn wisdom from those who are shaping the present general changes in engineering courses, and not attempt to teach all the special uses found in engineering work. The responsibility for teaching engineering practice rests on others. Some think a subject in contracts, for example, should be included in an engineering course, and some think it should not; but in any case it does not belong to the English department. So with commercial correspondence, bibliographical work, the uses of indexes, the making out of technical reports, and all such subjects. The process of arranging, recording, indexing, and preparing for communication, oral or written, is an important part of engineering work, the efficient management of which should be the serious study of someone. Some schools include training of this sort

in a course in the economics of engineering or in a course in administrative engineering. Other schools do not feel that they can undertake such a special department of instruction; but in such cases the head of each engineering course should see that the students under him make the most of their opportunities to get instruction in these subjects and are properly prepared to pick up engineering practice when they get to work. Toward this end the teachers of English can well assist, and their training in English should lead up to it; but the responsibility rests on the teachers of engineering. In most of the schools I visited there is at least one head of a department who does some little of this work, and I found that when the work was so done it was much more effective than when it was attempted by teachers of English alone. Furthermore, if there is not such training throughout the whole course, even the best results which the teachers of English can bring about in the first and second year are almost certain to be lost long before graduation. English as a matter of practice can be properly taught only when every teacher in the school is a teacher of good English, as every teacher in the schools of England and of France is a teacher of the native tongue.

2. On the other hand, much of the responsibility for English training should be placed on the preparatory schools. In the past their work has generally been far from efficient. Instead of taking advantage of the educational opportunities offered by the various occasions on which the student has to use his native tongue, instead of properly correlating language study in English and in foreign languages, instead of correlating history and literature, instead of studying the individual and attempting to develop his actual powers of interest and of appreciation if only a slight amount, the schools have been forced, mostly on account of the demands of colleges, into spending all their time in preparing to meet cut and dried entrance requirements. But a better understanding of the real needs is growing rapidly, and some little improvement has apparently been made already. The old course preparatory for college had a strong backbone of classics; the present

course preparatory for engineering schools has no backbone, or rather it often has a "chocolate eclair" backbone of pseudo-science, laboratory practice, and shopwork, which have to be largely unlearned in college. It is well within the possibilities to make the subject of English at least an important part of a real backbone, and I believe it would be greatly to the advantage of engineering schools if they would unite and use their influence to that end.

With the work of the teachers of English thus limited at both ends, there would be enough left for them to do, and that should be done with the highest efficiency. In the first place, the English department should give a thorough grounding in the fundamental principles of expression (which is mainly training in thinking), presented in the mature form that befits the college. Much of the material for this work can best be found in connection with the technical subjects in which the students are specially interested. And this training should be continued throughout the course under the charge of the teachers of technical subjects. In the second place, in connection with this training in thinking and in expression, and in addition to it, the English department should place before the students, in a form which they will be interested in and can appreciate, all it can of the almost inexhaustible possibilities of general education offered by literary composition and by the study of literature.

ELECTRICAL DESIGN FOR TECHNICAL UNIVERSITIES.

BY CHAS. R. MOORE,

Asst. Professor of Electrical Engineering, Purdue University.

INTRODUCTION.

It has been found by the writer that many different opinions are held by engineers and teachers generally as to what is meant by the term "electrical design." Especially is this true when technical courses in electrical engineering are under discussion, for it is here that the ideas differ radically. To some, electrical design means the substitution of constants, etc., in empirical formulæ, to others the preparation of drawings and the cultivation of the designing eye. Some doubt the value of carrying out a design at all unless the student can carry the work further and build his creation. Others hold that design courses should be elective, since only those whose temperament seem adapted to such work will then take up the study.

The writer has met men who doubted seriously whether the undergraduate student could be expected to do very much with design work at all, since the experience of most students is zero so far as the selection of design constants, shop practice, etc., is concerned. The writer believes, however, that plenty of calculation work in the way of designing electrical apparatus is essential to the correct understanding of theory and that such work should be required of every candidate for graduation. After the various formulæ and theoretical matters have been carefully studied, and developed, the student should have ample practice in their application to the predetermination of the characteristics of electrical apparatus. Engineers as a rule have little time for mathematics, but it is the conviction of the author that if concrete examples in

the way of finished machines had been worked out, and if the poetry of the calculus had been illustrated by its practical application to actual apparatus, even though some of the mental gymnastics required by the earlier portions of the regular course in mathematics must be sacrificed therefor, there would be fewer technical graduates faltering at the appearance of an integral sign. It is an old saying that we learn to do by doing.

Much has been said and written concerning laboratory courses, and the finest equipments have been installed with which to illustrate to the student the practical working of electrical apparatus, but the teaching of design seems to have received much less notice than is undoubtedly due it. It is not the purpose here to belittle in any way the effective work now being done in the electrical laboratories of our technical schools. Such work is highly important and has a large place in our curriculum. However, the development of mind incident to the taking of data, running of tests, and the working out of performance curves on a particular machine or type of apparatus that is already built, is far different from that received by working up and comparing various designs to do a specific work. Students may be given diagrams of circuits and instructions as to how to perform, calculate, and write up certain experiments, yet it is possible for him to do the entire work in a perfunctory fashion, miss the meat of the experiment, and fail to grasp the fundamental principle involved. By carrying out the complete calculations for a few machines, however, and making comparison, the student can hardly fail to grasp most of the essentials involved in that type or class of machines.

It is an easy matter to determine the characteristics of a machine already constructed as compared with the design of one to have predetermined characteristics. The predetermination of characteristics of electrical machinery and circuits is the most effective method of acquiring a thorough knowledge of fundamental laws. The student should be taught to realize early that accuracy and good judgment

must enter into the design which is to be of merit; a knowledge and training in the general fitness of things is essential.

It may be well to digress just here long enough to say that the student should be subject to the same rigor and discipline in school as will prevail when he enters the service of others. Furthermore, the intructor in charge should be more than a ruler, and the human side of the work as a whole should not be lost sight of. He should do something more than simply hold his job. These points are details, but the author believes that the product of our technical universities could be materially bettered if somewhat stricter laws concerning the administration of the work were laid down and enforced by the faculties.

Confidence of the student is imperative. If he can be made to feel that the material offered for his mental digestion is up-to-date and the best available the work will progress smoothly. Parts of the work not fully understood by the instructor in charge should be freely confessed and the mind of the student put at ease. Constant drilling in fundamentals should be the slogan.

It is the purpose of this paper to discuss what electrical design as applied to the technical school means to the author and to present an outline of a course designed to meet the requirements of the interpretation given. It is hoped that a paper of this sort will not be without interest to teachers and engineers alike.

General Considerations.

It is the first duty of the technical school to train men to think; how best to do it is the problem of the teacher. It is well known that a genius needs little education in order to be successful, but the fact remains that the world's work cannot be carried on by genii; they are too few, hence the advisability of training men of average ability.

Experience has shown that the man of average or mediocre ability if properly trained in the use of fundamental phenomena can become a useful and valued practitioner in the

engineering world. Many such men have shown themselves capable, after such training, of carrying responsibility with credit to themselves and their educators. Often they become leaders and engineers of reputation. Likewise men of large ability when trained technically become more effective leaders than they otherwise would have been. This point is universally conceded by engineers and business men alike. The question, then, no longer deals with the desirability of technical training but rather with the efficiency of the same.

Technical education may be defined as the gaining of a large mental experience in a short time. No man of whatever genius or natural ability could in the space of a lifetime, without help, re-develop and work out even the fundamentals of engineering and bring them to anything like their present state of perfection. It is imperative that every investigator thoroughly look over the experiences of men who have worked along similar lines before taking up his own work seriously. This work of acquainting the young engineer with the experiences of the master minds should be done by the technical schools; and experience shows that when this is carefully done there is little time left in a four-year course for the accumulation of cold data and unrelated facts. If, then, a course in electrical design is to best serve the interests of the embryonic engineers it must deal almost exclusively with fundamentals.

Thanks to the progressive men in design work, the art is becoming more and more a science, the importance of which is increasing with every succeeding year. The item of cost is highly important but the physical phenomena undoubtedly come first in educational work. First give the student experience in producing something that will work and discuss the cost of construction afterwards. The laws involved in the production of a design should be hampered as little as possible with empirical data. A casual survey of the more important developments of electrical engineering will convince anyone that the first problems have to deal with the physical working of the apparatus and as a theory is devel-

oped and methods of calculation are worked out the manufacturing details become less and less difficult. Therefore the kind of design work best adapted to the needs of the student must necessarily deal with fundamental laws rather than the curtailment of manufacturing cost.

Most of the large manufacturing concerns now have apprenticeship courses which may be likened to the hospital practice required of the medical student. Here the more practical side of electrical engineering is taught.

The highest service a technical school can render to the engineering world at large is to turn out thinking men well grounded in the principles of engineering, able to think for themselves, and possessing the proper attitude towards work.

The student should gain in school sufficient practical knowledge to be able to appreciate the value of physical phenomena, but the bulk of his practical training must of necessity come from experience with the world's work rather than from college texts. Given the proper raw materials any of the engineering concerns can supply this practical training and develop men useful to the firm and to the business world at large. Our undergraduate courses should not, therefore, be too highly specialized but should deal mostly with underlying theory and the application of physical phenomena to useful machinery and apparatus.

Course in Electrical Design.

In the development of the course in electrical design outlined in this paper a summation of the previous discussion has been kept in mind as follows:

I. The methods must be as free as possible from empirical formulæ and design constants. All calculations must be based on fundamental physics.

II. The course should give the student practice in the calculation of typical apparatus, the principles of which may be readily applied to special machinery.

III. Each design should be complete in itself, the characteristics of which must be predetermined.

IV. The drawings required are not finished drawings but only outlines from which the length of circuits, etc., are to be taken and with which the sense of proportioning may be cultivated.

V. The designs must be arranged in such a way that the completed course forms a logical line of study. The time contemplated for this work is one school year, preferably the senior year, of thirty-six weeks, eight hours per week.

The course is supplemented by recitational work in which theory and formulæ are developed and for which outside study on the part of the student is necessary.

Five designs are considered in the following order:

1. Rheostat or electric heater.
2. Electromagnets.
3. Direct current machine.
4. Alternator.
5. Induction motor or transformer.

Design 1. Rheostat or Electric Heater.—In this design the student is introduced to the calculation of electrical phenomena by so proportioning resistance materials that electrical energy is converted into heat at a definite rate and dissipated from the surfaces. The specifications given relate to starting boxes, regulators, and heating apparatus. It is in this design that the student becomes familiar with the common electrical units. No drawings are necessary in this design.

Design 2. Electromagnet.—The specifications for this design relate to traction magnets and solenoids. The student gains practice in the use of magnetic units and combines same with those used in Design 1. Continuously and intermittently excited magnets are worked out, and compared. As in the first design the student here calculates temperature rise and distinguishes between radiating and heat-absorbing power of apparatus. Such items as leakage flux, space factor of windings, etc., are worked out and studied. Plenty of time is devoted to the magnetic circuit itself.

An outline drawing only is necessary in this design.

Design 3. Direct Current Machine.—In this design the student combines the principles learned in the calculations of heaters and electromagnets and adds thereto those relating to moving parts. The specifications relate to generators and motors of standard types and the best proportions are found by trial. This scheme is used in order to emphasize in the student's mind the principles involved. The final dimensions are fixed by conditions usually of temperature rise. Catalogues are freely consulted.

The inductance of the commutated coil is worked out from fundamental formulæ rather than from curves or constants. This requires more time, but the efforts are well spent.

Air gap flux distribution curves are worked out for various loads, and the performance of the machine predetermined. One of the items resulting from such work is the brush position. This setting of the brushes, while of no great importance to the practical designer perhaps, is highly instructive to the student. To the writer's knowledge, the location of the brushes is always left to the men on the test floor. Tests show that it is possible to predetermine with reasonable accuracy the brush position. Another fact brought out by the load flux distribution curves is the shift of the magnetic neutral and the correction of the erroneous impressions concerning cross magnetization and de-magnetization of the field by a loaded armature.

Performance curves are worked up and plotted for this design. An outline drawing is required in order to cultivate the sense of proportioning and to get the lengths of the various circuits.

Design 4. Alternator.—Here the student is first introduced to the practical calculation of alternating current phenomena as applied to machines, and having gone through the previous designs no difficulty is encountered in attempting the design of a complete machine. As in Design 3 the proportions are found by trial and fixed usually by temperature rise. The inductance is worked out from fundamental formulæ rather than from constants for reasons explained in Design 3.

Air gap flux distribution curves are worked out for various loads and the E.M.F. wave form found by moving the coil as a whole beneath such curves and scaling the ordinates above it. This has been found to give a very close approximation to the true wave, where the slots are not too few and the pole corners well rounded. Performance curves and outline drawings similar to those required in Design 3 are made and studied. The specifications have to do with standard types of machines.

Design 5. Induction Motor or Transformer.—This design is intended to supplement Design 4 and to fix in the student's mind the principles already learned. In addition, the interesting circle diagram or the Steinmetz analytical method is used in working up the performance curves. An outline drawing similar to Designs 3 and 4 is required. The proportions are found by trial and fixed by temperature rise as in previous designs.

Through this course outside reading is encouraged and requested. References are given from time to time pointing out where researches experimental and mathematical, may be found, and current literature is also brought to the attention of the student.

Conclusion.

The benefits to be derived from such a course as outlined above are obvious. Upon the completion of this work the average student should be able to go into practical work and to interpret intelligently many of the schemes and processes displayed around him.

If he has the requisite personal qualities required by the business world he should have little difficulty in fitting into his proper place and becoming a successful engineer.

NOTES ON THE TEACHING OF ELEMENTARY PHYSICS.

BY W. S. FRANKLIN AND BARRY MacNUTT.

FIRST PAPER.

It is scarcely possible to over-emphasize the importance of laboratory work in elementary physics teaching. We have tried the system in which a young man is given experiment number so and so and told to read it up in a manual where a complete theory of the experiment is given, where the object of the experiment is stated, where the apparatus to be used is minutely described, and where the work to be done is completely specified. As might be expected, the result is an *entire lack of interest* on the part of the student and the *complete elimination of initiative* on his part. Recently our system of laboratory work has been altered. A *question* which will appeal to a young man's sense of values is now proposed to the student. For example, "How much heat gets into this particular refrigerator in twenty-four hours?" and the student is left to himself to think out the details of the test, coming to the instructor only when he feels hopelessly lost. Half a hundred exercises of this general character have been devised and the response of the young men is something good to see.

The following notes on the teaching of physics refer wholly to lectures and text-book work.

SAMPLE EXAMINATION QUESTIONS AND RESULTS.

One hundred and sixty-four freshman engineering students who had taken elementary mechanics for half a year were tested on the following questions:

1. A man weighing 160 pounds sits on a seat in a boat, braces his feet against a cleat and pulls on an oar. What forces act on the man and by what is each force exerted?

2. A hoop around a tank has a tension of 1,500 pounds and the diameter of the tank is 20 feet. (*a*) How much work is done on the hoop when the tightening bolt is shortened 0.001 foot? (*b*) How much work is done on the tank by the shrinkage of the hoop? (*c*) How much work is done on the tank by one foot of the hoop? (*d*) What is the inward movement of each part of the hoop expressed as a fraction of a foot? (*e*) What force is exerted on the tank by one foot of the hoop?

3. The force required to drag a boat is, let us say, proportional to the velocity of the boat. It takes 10 horse-power to drag a boat at a velocity of 10 miles per hour. How many horse-power will be required to drag the same boat at a velocity of 12 miles per hour?

RESULTS.

Grades.	Percentage of Class Making Various Grades.			Average Number of Words Used by Men of Each Grade on Question 1.
	Question 1.	Question 2.	Question 3.	
9–10	23	15	4	37
8– 9	10	18	—	55
6– 8	14	21	—	60
5– 6	31	5	—	52
4– 5	15	16	—	57
0– 4	8	26	96	53

During the first half year the principle of action and reaction was discussed in class and illustrated by referring to a man in a boat, and the great number of words used in answer to the first question was, in most cases, the uncalled-for discussion of action and reaction. There is a tendency for everything that has been associated with a given matter to be dragged by the student into any discussion concerning that matter, and this tendency is exhibited most strongly by the poorest thinkers.

It is very difficult to make a student deal with ideas when he is writing an examination. We therefore try to plan our examination questions so that the student cannot use formulas. The second question furnishes a good example. If this same

problem had been stated in a formal way, demanding only the final result and asking for an explanation, at least 85 per cent. of the class would have made a passing grade. This question was given a second time to the same group of men in final examination, and, in spite of the fact that the question strongly suggests the successive answers to any one who has any physical sense, a large percentage of the men persisted in working backwards "from the formula *tee* equals *eff arr*" to get answers to (*e*) and (*d*) and (*c*)!

No question like the third had ever been discussed before the class although 95 per cent. of the class were certainly familiar with the fact that the power developed by a force which acts on a moving body is equal to the product of the force and the velocity of the body in the direction of the force. The results of this question show how thoughtless students can be. Indeed it is probable that what sometimes seems like thoughtfulness in an examination may be only a remembrance of things previously discussed or previously thought out.

The great majority of young men cannot realize the meaning of simple English when it is impersonal and non-anthropomorphic, and a large proportion of the failures in answer to the above questions were due, no doubt, to the inability of the men to read the questions intelligibly.

How to Make a Statement of Principle or Fact in Physics.

Recently, in discussing the principle of the conservation of energy before a group of college Sophomores, the following two statements were contrasted:

(*a*) Energy can be neither created nor destroyed.*

(*b*) The work done by a weight depends only on its initial and final positions, and it is hopeless to seek a roundabout

* To substitute for this the statement that when one system gains energy another system must lose an equal amount of energy does not lessen the contrast.

method for bringing the weight back to its initial position by the expenditure of a lesser amount of work.

The first statement carries with it no physical suggestion whatever. The second statement touches the very essence of the principle of the conservation of energy because it refers to the *definiteness of potential energy* which IS the principle in its purely mechanical form; and above all, the second statement calls to mind a form of test or trial. *Every statement of principle or fact in physics should take a form which suggests trial and verification and every physical definition should take a form which suggests the underlying physical operation.* This suggestion makes a statement or definition sensible in the strict meaning of that term, whereas the absence of this suggestion leaves only non-sense.

An examination of elementary treatises on physics reveals an almost total absence of sense in the meaning here referred to, except, only, where pure description relieves the "pale cast of thought." Indeed many of us look longingly backward to Ganot's physics and wish that we could use it with our students; perhaps it would be better than anything we now have; but we cannot escape the demand for rationalization. This demand must be met and it cannot be met by a senseless philosophy.

Sense and Non-sense.

The following is a good example of the kind of non-sense which is involved in the absence of all suggestion of trial and verification in physical statements. To appreciate this example one must remember that *the fundamental fact concerning fluid pressure is that a fluid at rest exerts a normal force upon an exposed surface.* This fact is fundamental because it is immediately verifiable by experiment, and being immediately verifiable by experiment, the statement of it suggests trial and verification. All ideas concerning internal force actions in fluids at rest are properly inferred from this fundamental fact.

"Fluids at Rest. Fluid Pressure. A perfect fluid is a body which would offer no resistance to a shearing stress.

This, as we have seen, is a purely ideal case, but if we consider the distortions in a fluid mass as vanishingly small, even the slight resistance of the fluid to change of form arising from viscosity becomes zero, and we find that fluids at rest behave as perfect fluids. Since in a perfect fluid there is no viscosity, and hence no statical friction, it follows that the pressure exerted by the fluid on the containing vessel must all be normal to the surface of the vessel, because any pressure other than a normal pressure could be resolved into a normal and a tangential component. The normal component would produce pressure on the side of the vessel; the tangential component would produce motion in the fluid unless opposed by statical friction. But there is no statical friction, and since the fluid is at rest, there can be no tangential component. Therefore the fluid pressure on the side of a vessel is normal to the side of the vessel."

Another example of pure non-sense is the usual statement of the second law of thermodynamics. No one ever saw heat and we know only indirectly what a flow of heat is, and it is therefore ridiculous to put forth as the second law of thermodynamics the statement that heat cannot of itself flow from cold to hot. Truly, the old nursery rhyme of Humpty Dumpty is a much better statement, but Humpty Dumpty includes more than the second law of thermodynamics as at present understood.

The idea that the second law of thermodynamics has anything in common with the "tendency of energy to change from the potential to the kinetic form" is not only non-sense but it is unqualifiedly false. Approximately the whole of the convertible energy of a compressed gas is kinetic energy, according to the atomic theory, and when a compressed gas squirts through a hole the energy is still kinetic. One may choose, of course, to look at the whole thing from a mechanical point of view and consider the energy of a compressed gas as potential energy. In this case the energy does change from potential to kinetic as the gas squirts into the hole but the Humpty Dumpty business takes place as the squirt comes out

of the hole when the kinetic energy (mechanical) of the squirt is converted into heat. The essence of thermodynamics is that it refrains from describing what takes place in an irreversible process, and nothing in the whole realm of sense-less physics is quite as ridiculous as the pretended description of an irreversible process as a conversion of potential energy into kinetic energy.

Algebra versus English.

The ease with which a young man's attention can be turned away from the simple experimental bases of physics is the salvation of many a teacher of physics, and his salvation is made the more certain by a generous use of algebra. Except for this important reason, algebra should be reduced to a minimum in the study of elementary physics. Only the most fundamental relations should be expressed by formulas, and purely algebraic developments growing out of these fundamental expressions should be omitted.

A great majority of advanced text books on the theoretical phases of technology, where it is, of course, necessary to deal extensively with algebraic developments, are open to the serious criticism that the physical basis of the discussion is almost entirely lost sight of and in many cases never even mentioned. A good example of this is a well-known treatise on alternating currents. The author is very remarkable for his physical insight, and his discussions before engineering societies are always wonderfully clear with direct appeal to sense material. In the book referred to, however, the author takes for granted the connection between physics and algebra; in this the author is not blameworthy, but it is pitiful to see users of his book mistake algebra for physics. A treatise consisting chiefly of algebraic developments cannot even be called theoretical in the proper meaning of that term. The most striking example, however, of the entire subordination of physics to algebra is what is usually placed before students of engineering under the name of thermodynamics.

The Object of Elementary Physics Study Should be to Develop Rational Insights.

If the object of the study of elementary physics is to develop a few rational insights, everything should be omitted from the study which either is not familiarly known to the student or which is likely not to become familiarly known to him as a plain man, and everything should be omitted which cannot be rationalized in terms of principles within the reach of young men. It is not the duty of a teacher of elementary physics to give his students a survey of the science.

Most teachers seem to think that ideas can be built up in young men's minds by a sort of hocus pocus, out of nothing; but, like everything else in this world, ideas must be made out of something, and the problem of rationalizing physics in a young man's mind is in part the problem of how, by suggestion or otherwise, to drag sense material into his field of consciousness where it may be transformed into ideas.

Elegance versus Homeliness.

Several years ago a Freshman was asked in recitation to explain what is meant by the heat of combustion of coal and he answered saying that "It is the amount of heat obtained from a pound of coal." After trying in vain to lead the young man to add the further statement "when the coal is burned," the instructor asked "But how do you get heat out of coal?" To which the student answered "Why . . . Professor . . . I don't know." Of course, he did know but he imagined that the study of physics from a book in college must relate to elegant things.

And it is before such young men that we lay out our bookish wares and interminable elaborations of detached theory! And we teachers of elementary physics are by no means the worst offenders; that distinction belongs to the teachers of such ostensibly practical subjects as the theory of the steam engine.

Es erben sich Gesetz und Rechte
(und heutzutage auch die sogenannte Technologie)
wie eine ew'ge Krankheit fort.

The Justification of an Hypothesis is its Use.

In a well-known physics text the wave hypothesis of light is clinched and all embarrassment and uncertainty is eliminated by the statement that "any effect which is periodic and which is propagated at a definite velocity is wave motion." To read this statement and to have pop into one's mind a vision of the Gatling gun of which the effect is "periodic and is propagated at definite velocity" is amusing; but to see such stuff placed before students is appalling. Wave motion is not essentially periodic (neither is light for that matter), and one who understands the difference between *wave velocity* and *group velocity* knows that wave motion is not necessarily propagated at a definite velocity. An attempt to justify an hypothesis such as the dissociation hypothesis in electrolysis or the wave hypothesis in light by plausibilities is the emptiest kind of scholastic vanity.

Force and Mass.

Young men have a great deal of difficulty in clearly appreciating simple matters of fact, as is shown by the answers to the above questions, and the only way of leading a young man to a clear appreciation of physical principles is by setting forth distinctly the things which come from experience and then proceeding on the basis of this material to the development of the ideas of the subject. No student can be expected to profit by the discussion of fine abstractions such as are involved in the usual presentation of the laws of motion and the idea of mass, where the teacher shows a beautiful contempt for concrete experience, refusing to refer to the muscular sense as giving the fundamental idea of force, and talks about the measurement of the mass of a body by moving (sic) it about, in noble contempt of his coal dealer who measures his coal, falsely, on a balance scale!

In the name of all that is determinate, let us define the mass of a body as measured by a balance scale, and then let us try to lead our young men to understand as an experimental fact that the acceleration produced by a given force is inversely proportional to the mass of the body upon which the force acts.

It is with some reluctance that we mention this question of force and mass, so much that is not edifying has been written upon it. Our object in broaching the subject is to call attention to the remarkable discussion by Larmor on the "Scope of Mechanical Ideas." No one nowadays should presume to talk philosophically about force and mass unless he has read and understood Larmor's discussion. This latter condition might indeed shut most physics teachers' mouths, and it would be a blessing to their students if it could be made to operate in this way. Indeed, the recent discussion of force and mass by physics and engineering teachers is of significance only as exemplifying the insanity of fixed ideas!

Machines and the Idea of Energy.

The idea of energy has become so dominant in the minds of physics teachers that they have almost come to look upon physical science as a one-dimensioned complex—without any remaining attribute of complexity. For example, in nearly every current treatise on elementary physics, the narrow technical meaning of work is properly insisted upon, and then, ignoring everything but energy relations, a machine is defined as a device for transforming energy or for facilitating the doing of work. Very well, a sewing machine facilitates sewing and sewing is work. A loom facilitates the making of cloth, and the making of cloth is work. A steam shovel facilitates the digging of dirt, and the digging of dirt is work. Every boy knows as much. But how about the narrow technical concept of work?

The fact is that machines have an important physical meaning which the one-dimensioned physicist seems to despise, and this unrecognized meaning, which is the whole meaning of

machines to the men who use them, will sometimes be generalized as an idea as broad as the idea of energy, and a second dimension will then be added to pedagogical physics!

The new generalization will refer to a kind of *equivalence of complexes*. Complexes are not exactly conservative, for everyone knows that bridges rot and houses fall into decay, but they are somewhat like things that are born in that they always have antecedents and do not come out of nothing. He surely is a non-physical physicist who has not pondered as to what it is in a masonry structure that costs so much, when stone can be had for the digging and energy costs nothing except the trouble of gathering it together and applying it—and letting it all escape in the process!

All this may seem to be vague and beside the mark but it is necessary as a preliminary to the statement that the idea of energy is altogether too greatly exaggerated in the philosophy of elementary physics. To call the idea of energy as it exists in most teachers' minds an obsession, is to put it too mildly. Any boy knows that a sausage grinder is used to grind sausage, and every boy in his naivete knows that the man is a fool who describes a sausage grinder as an energy-transforming device.

Current Text Books of Physics.

This paper has been fully discussed by the teaching staff of the Department of Physics of Lehigh University and many important suggestions have been made by the younger members of the staff, despite the fact that our departmental discussions are so informal that the youngest member of the staff has been led to remark that our regular weekly conferences are as good as vaudeville. One instructor, true to this flippant spirit, suggested that this paper be entitled "A review of so and so's elements of physics" so that the paper might attract readers and make them angry. We hope indeed that the paper may attract readers, and we trust that it may make many of them angry, but we refrain from making any such specific application. We assume that every teacher recognizes

sorely the need of what Bacon listed as a deficiency in his day, the Traditive Lamp or the Proper Method of Delivering Down the Sciences to Posterity; and we assume that no author of a physics text book is wholly pleased with what he has done. But especially, recognizing the great predominance of what may be variously called ideas or method or theory in what is teachable in science, we recall another humiliating passage from Goethe

> Grau, teurer Freund, ist alle Theorie
> Und grün des Lebens goldener Baum.